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(54) **LIGHT SOURCE DEVICE AND ELECTRONIC APPARATUS**

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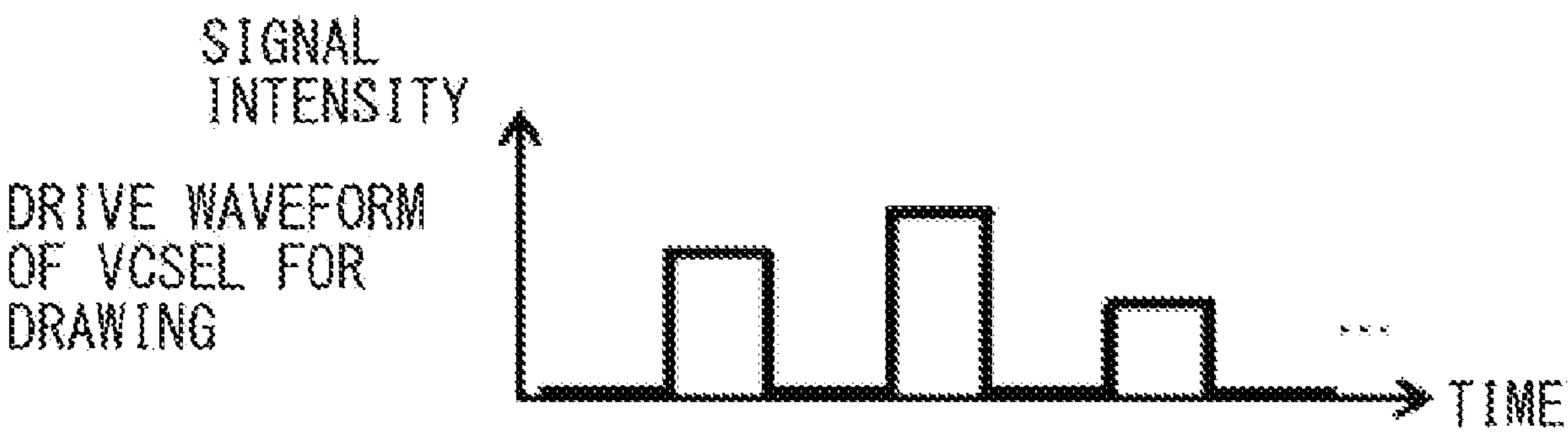
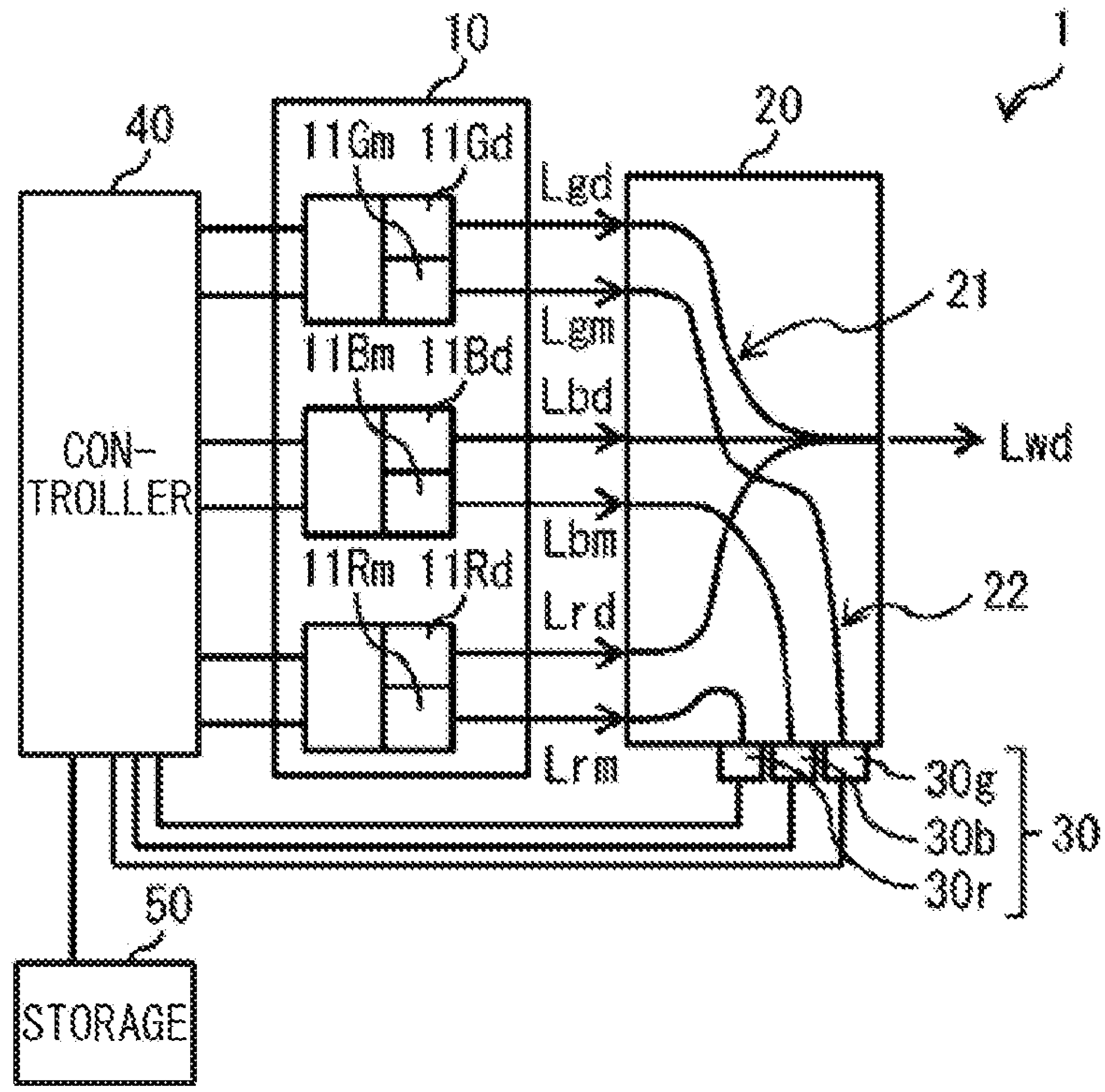
(57) **ABSTRACT**

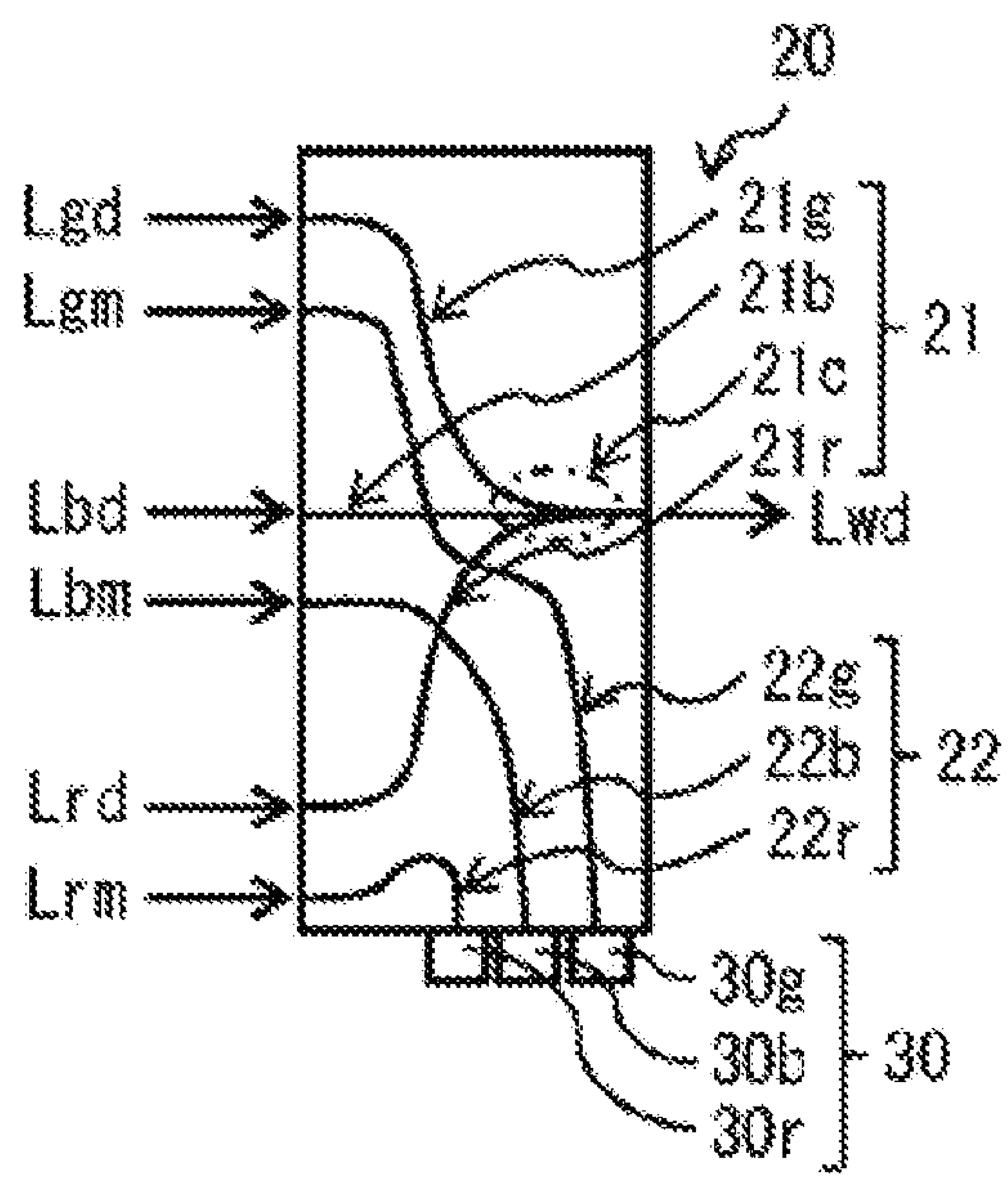
A light source device according to an embodiment of the present disclosure includes a first light source section that outputs first laser light for drawing, and a second light source section that is provided adjacent to the first light source section and outputs second laser light for monitoring. The light source device further includes a light receiver that receives the second laser light, and a controller that performs light emission control on the first light source section on the basis of a detection signal from the light receiver.



[FIG. 1]


1
10
40
20
11Gm 11Gd
11Bm 11Bd
11Rm 11Rd
CON-
TROLLER
Lgd
Lgm
Lbd
Lbm
Lrd
Lrm
21
22
Lwd
30g
30b
30r
30
50
STORAGE

[FIG. 2]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Lgm
Lbd
Lbm
Lrd
Lrm
21g
21b
21c
21r
21
Lwd
22g
22b
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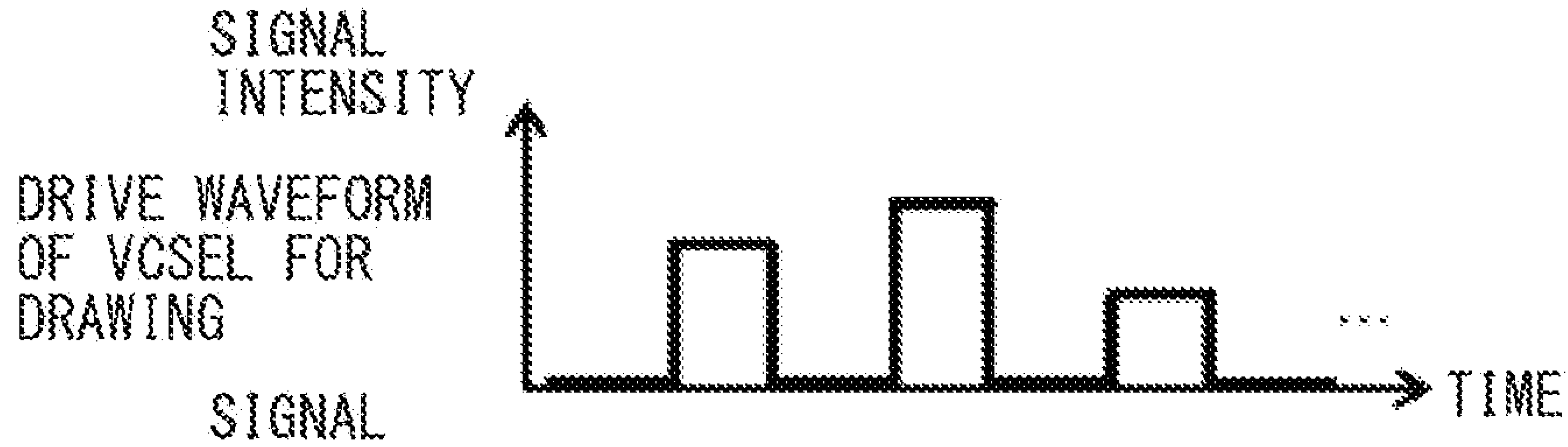
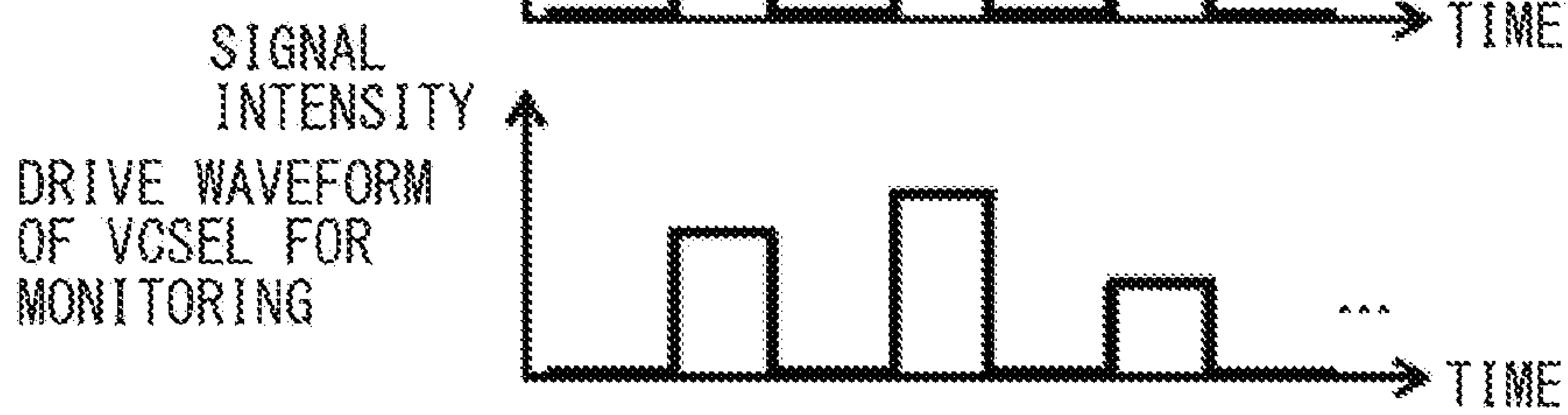
30b
30r
30

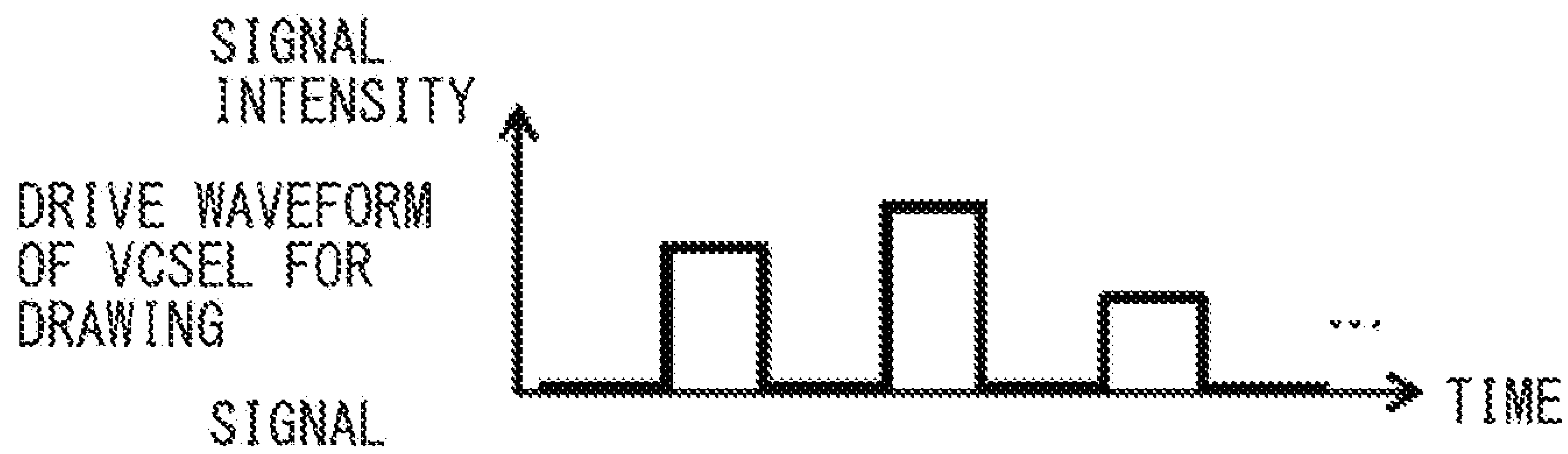
[FIG. 3A]



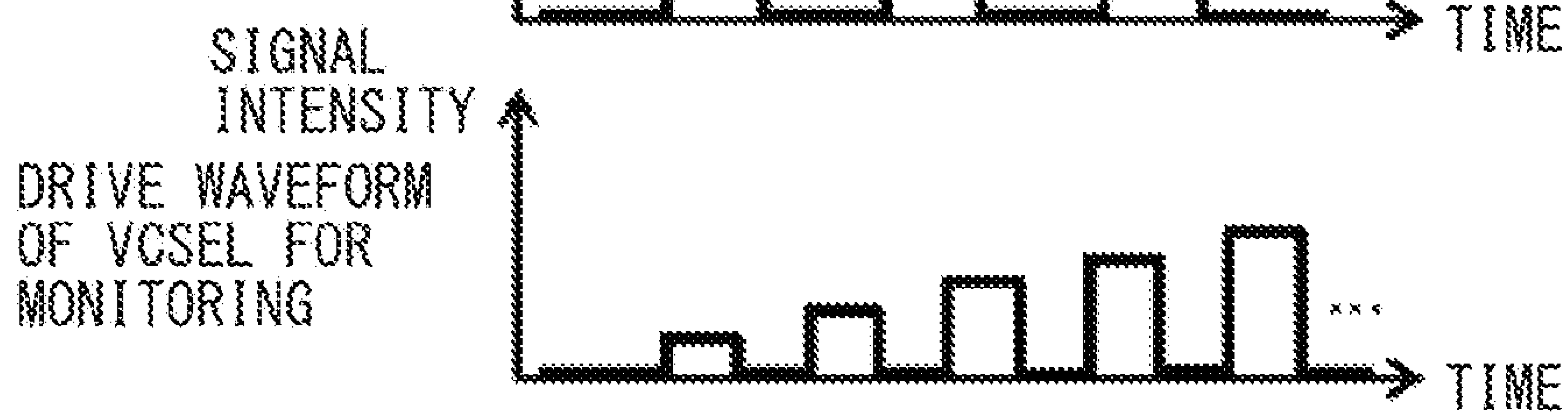
[FIG. 3B]



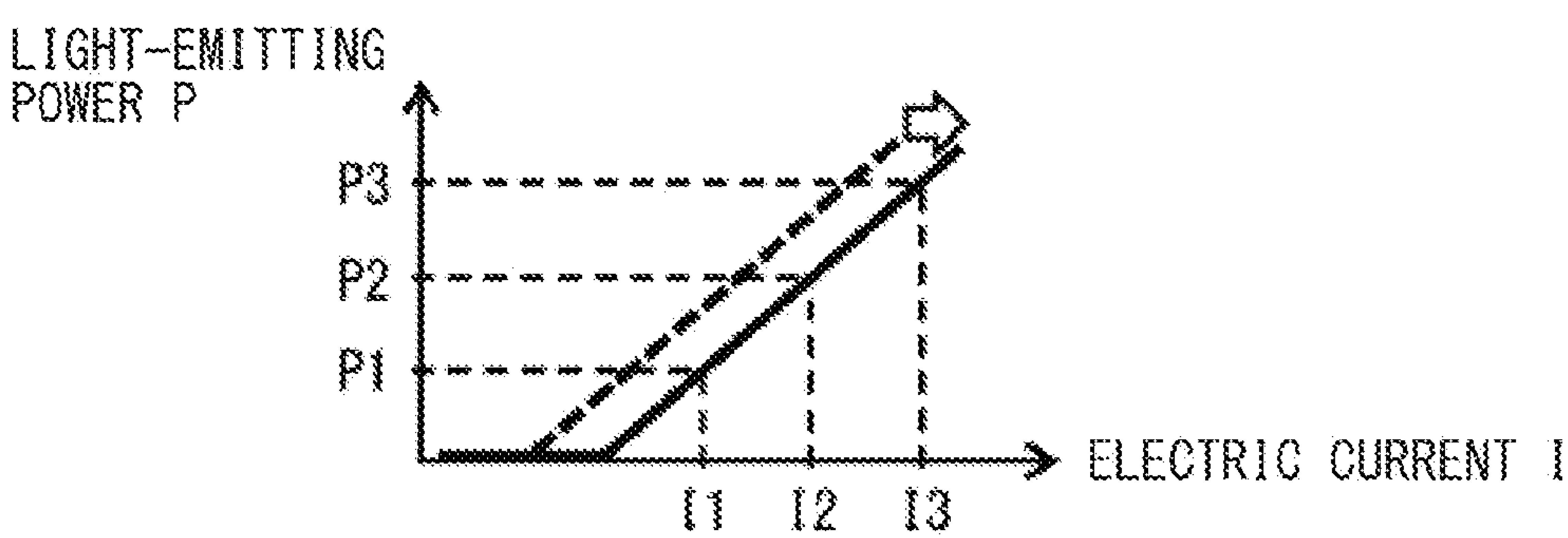
[FIG. 4A]



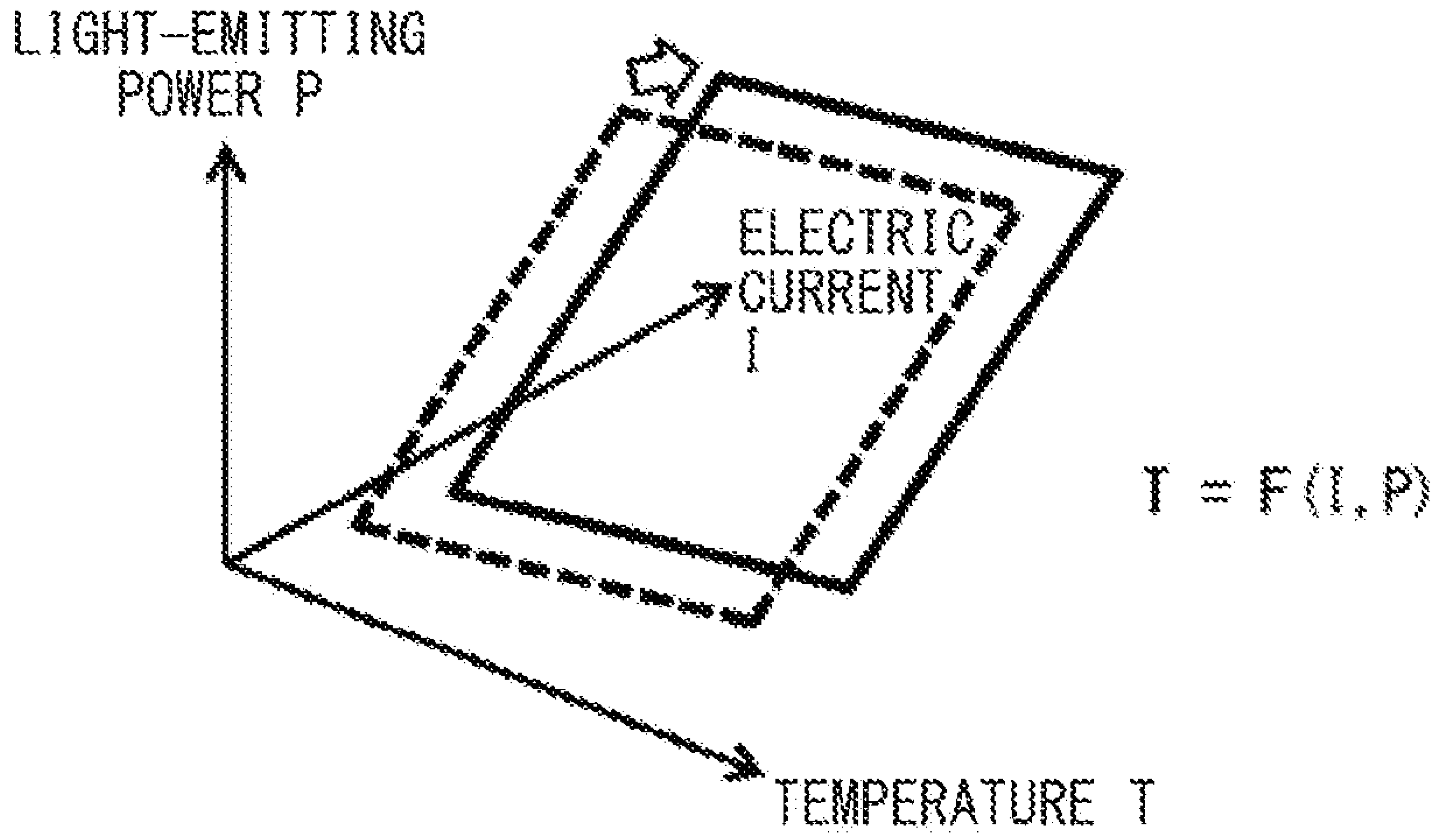
[FIG. 4B]



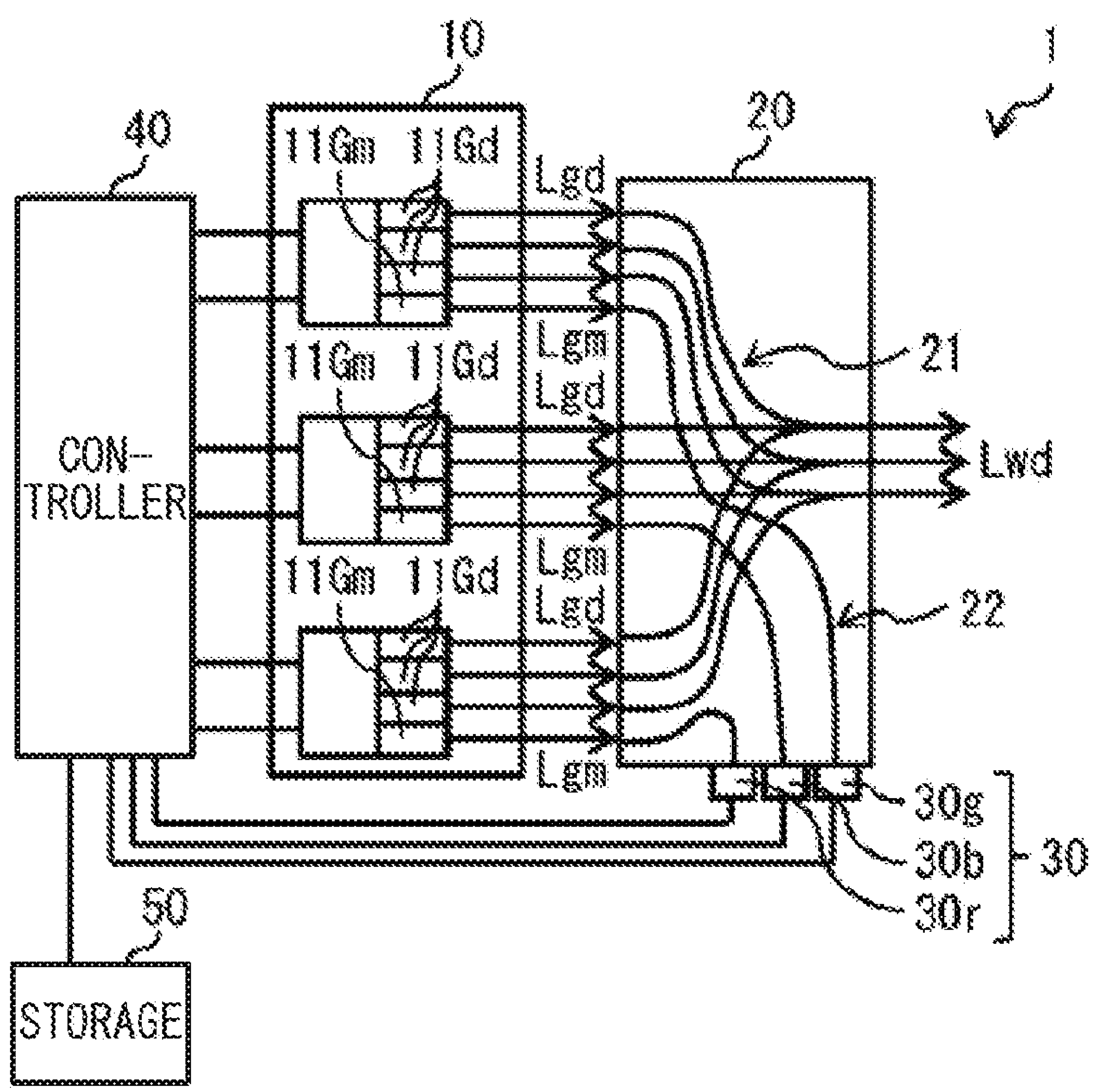
[FIG. 5]



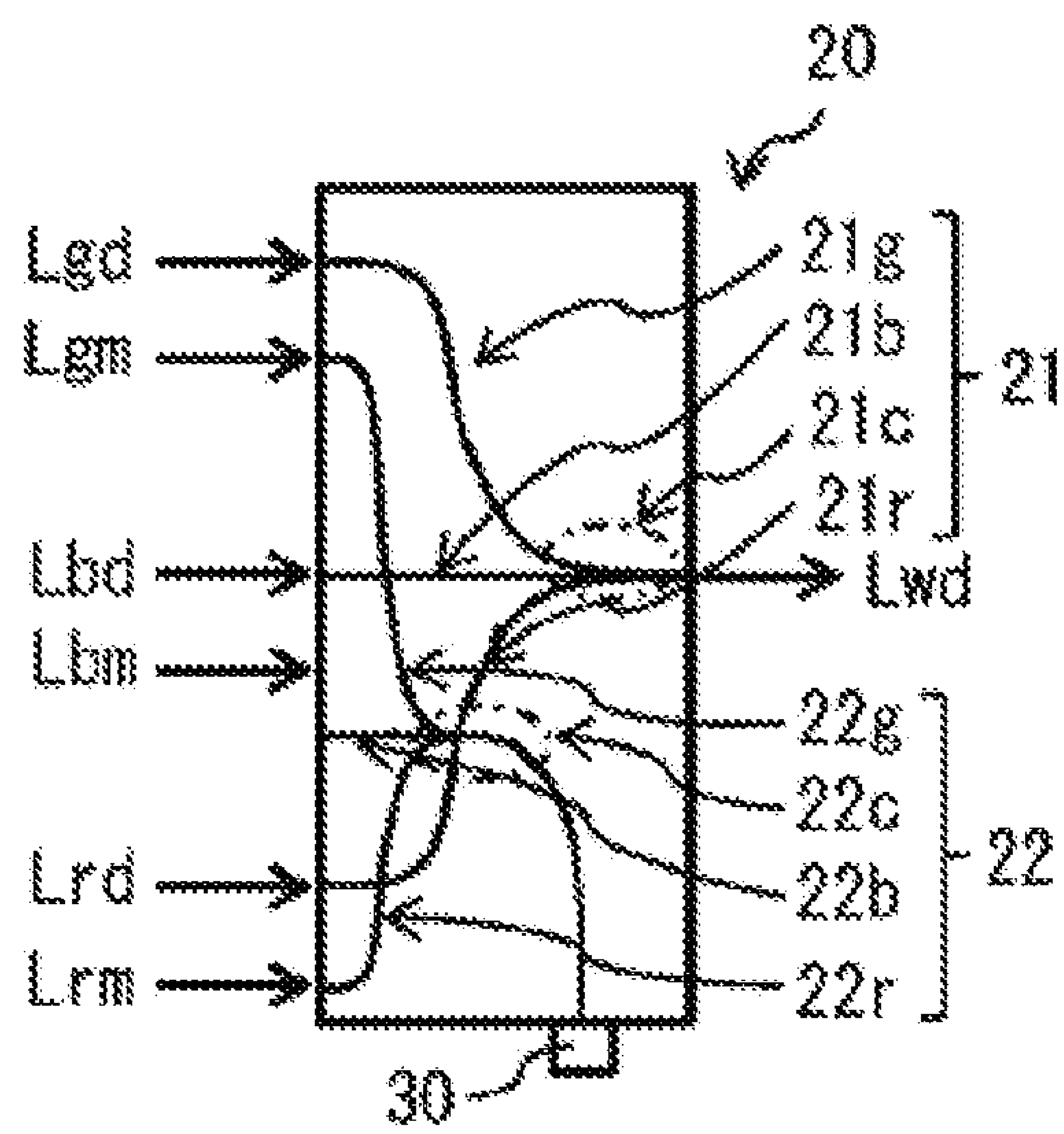
[FIG. 6]


LIGHT-EMITTING
POWER P
ELECTRIC
CURRENT
I
T = F(I, P)
TEMPERATURE T

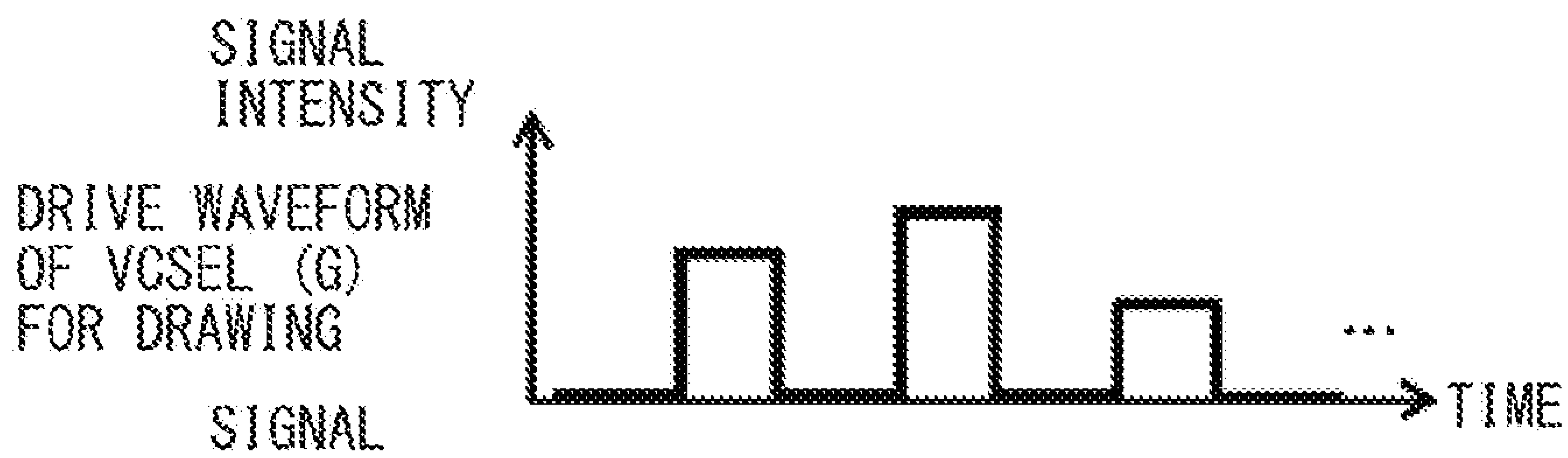
[FIG. 7]


10
1
40
20
11Gm 11Gd
Lgd
Lgm
21
Lwd
CON-
TROLLER
22
30g
30b
30
30r
50
STORAGE

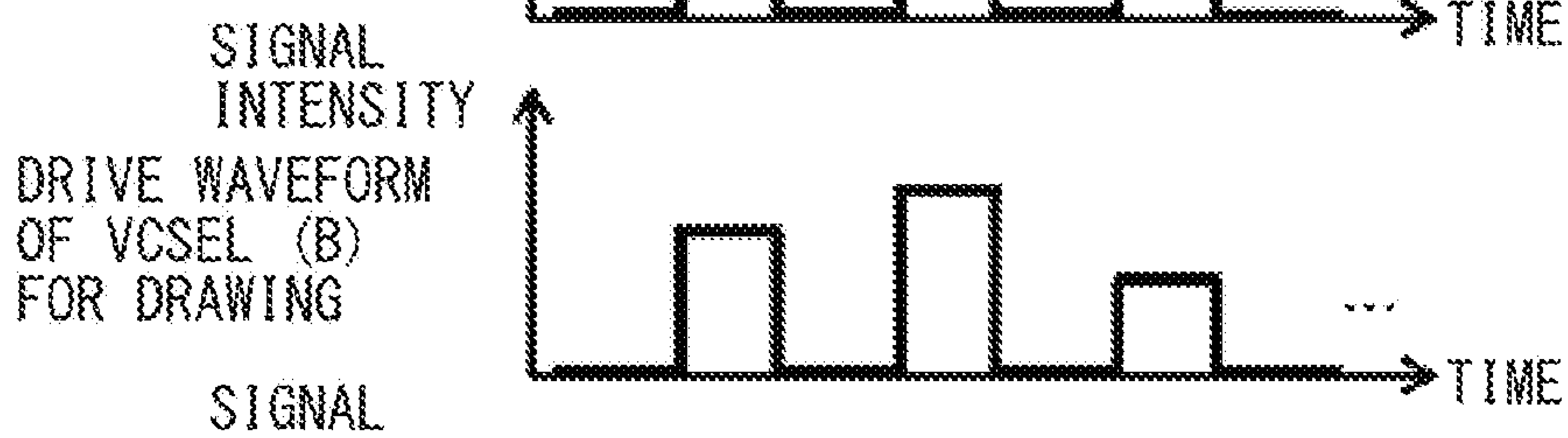
[FIG. 8]


20
Lgd
Lgm
Lbd
Lbm
Lrd
Lrm
21g
21b
21c
21r
21
Lwd
22g
22c
22b
22r
22
30

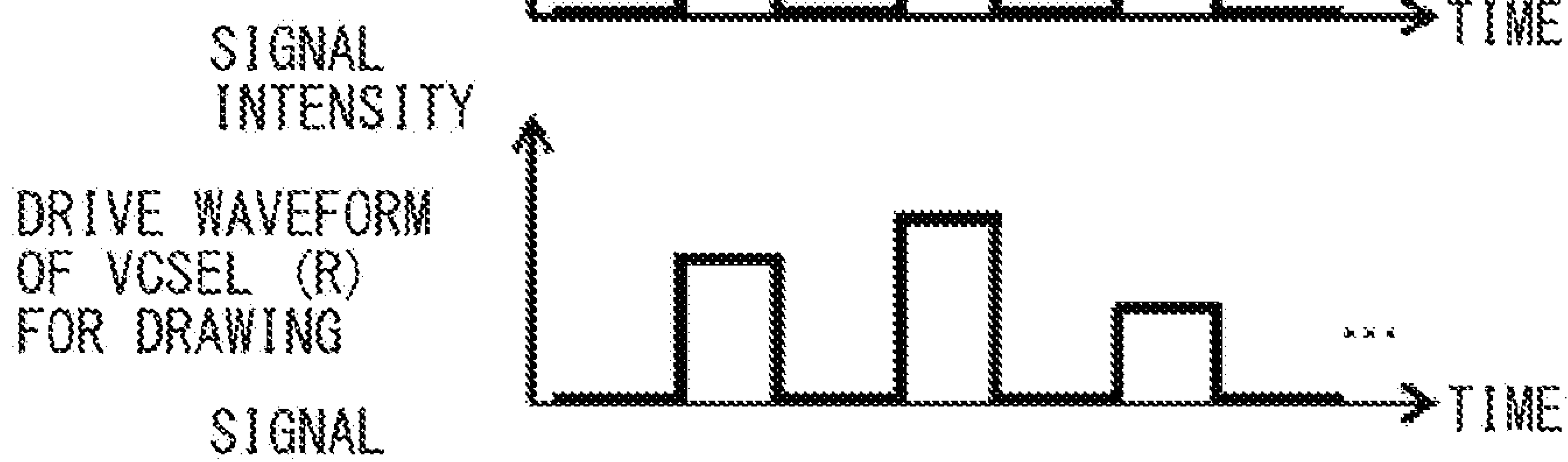
[FIG. 9A]



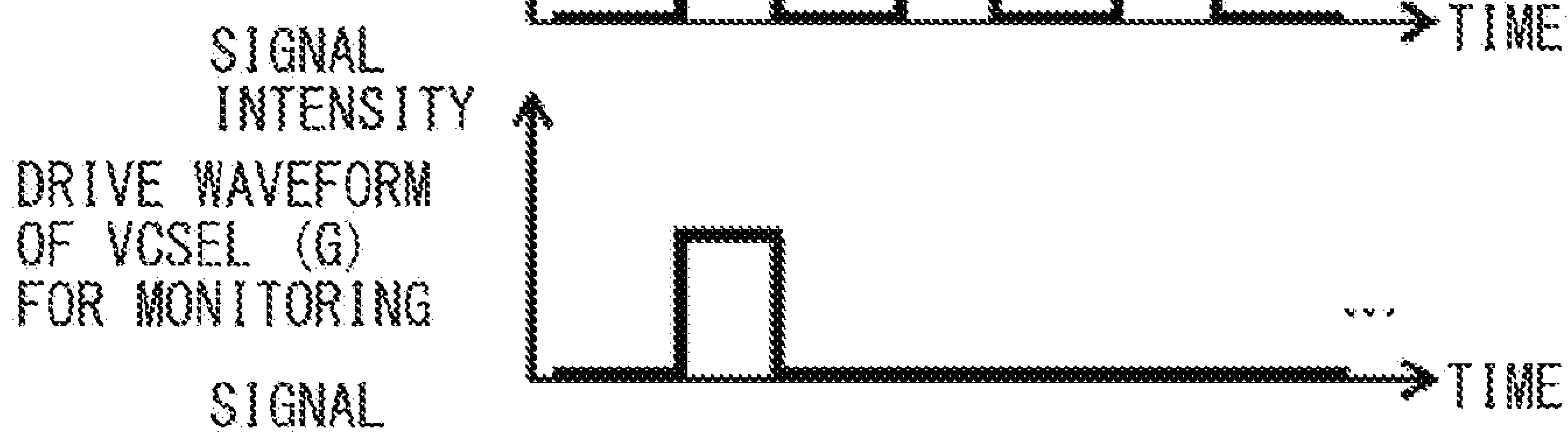
[FIG. 9B]



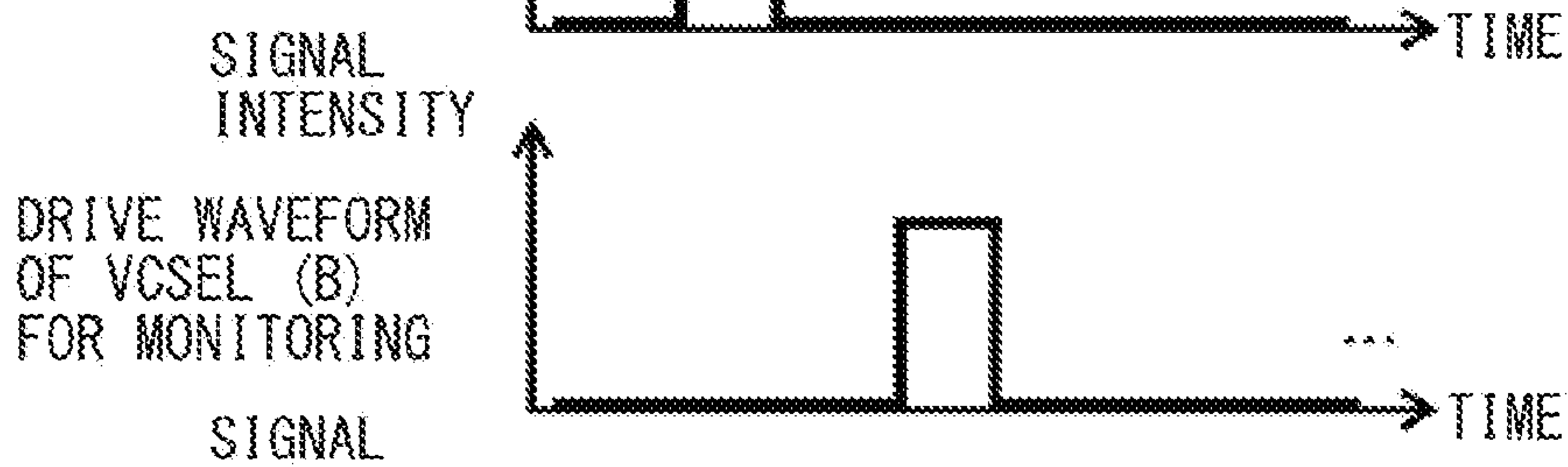
[FIG. 9C]



[FIG. 9D]

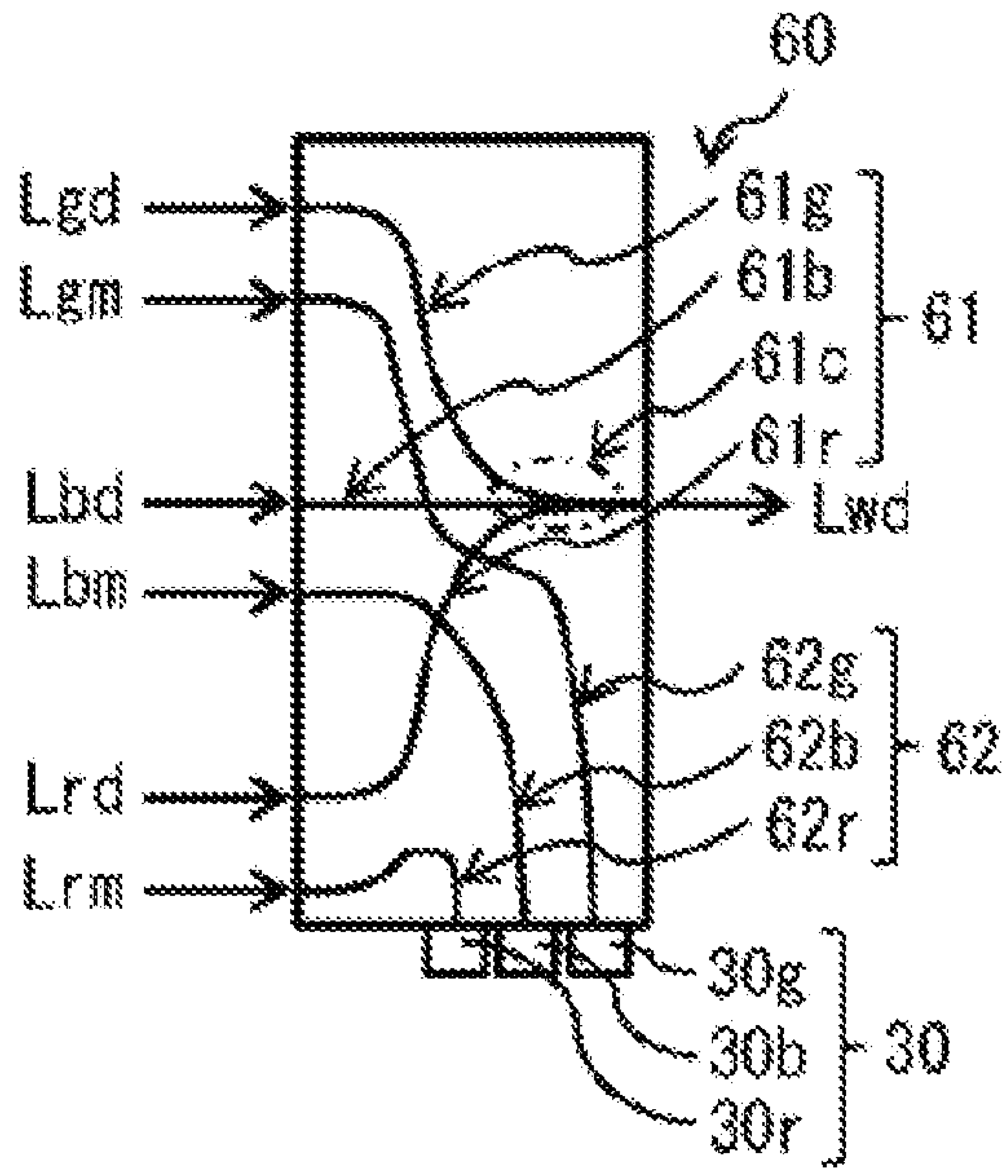


[FIG. 9E]



[FIG. 9F]

[FIG. 10]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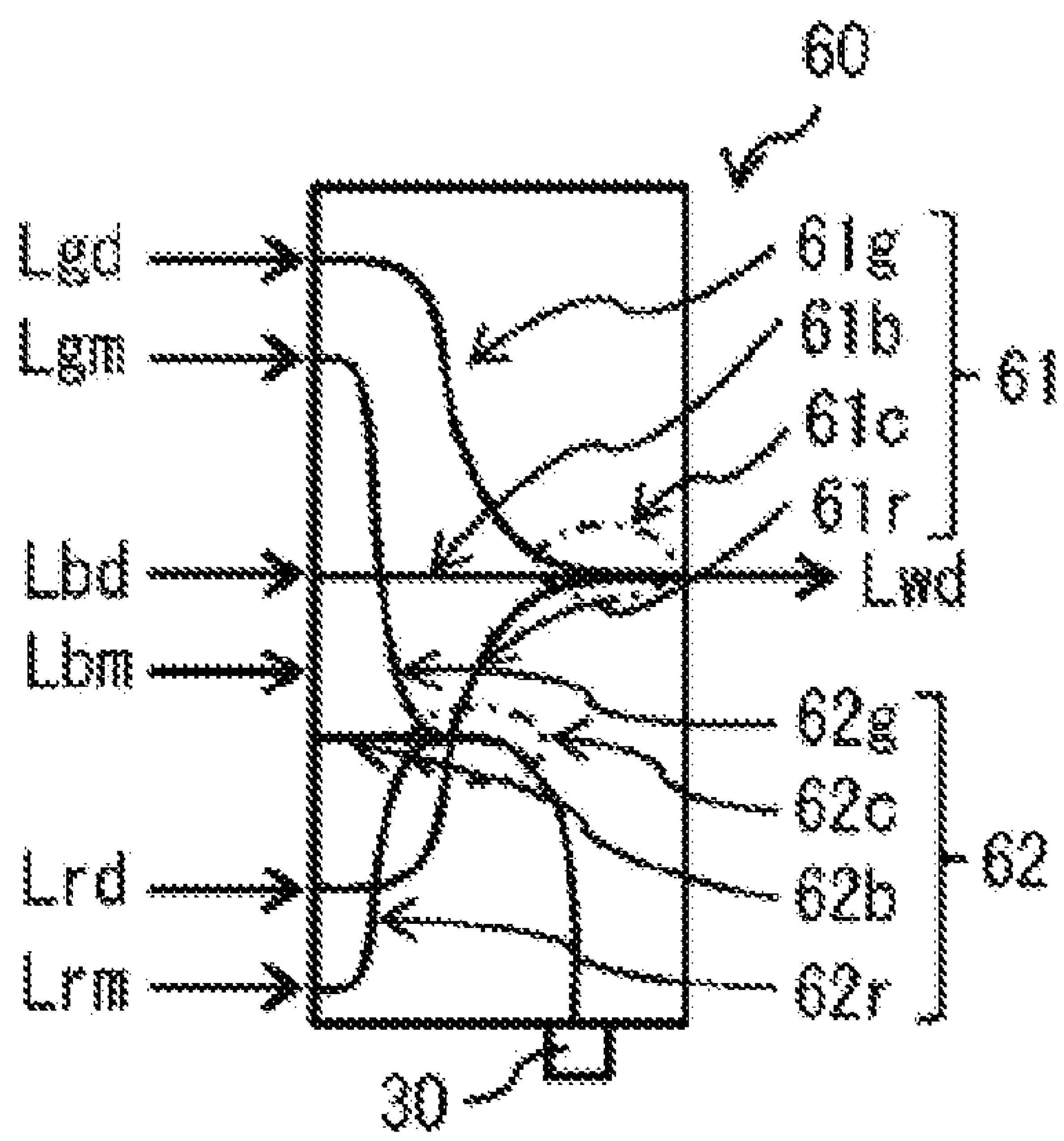
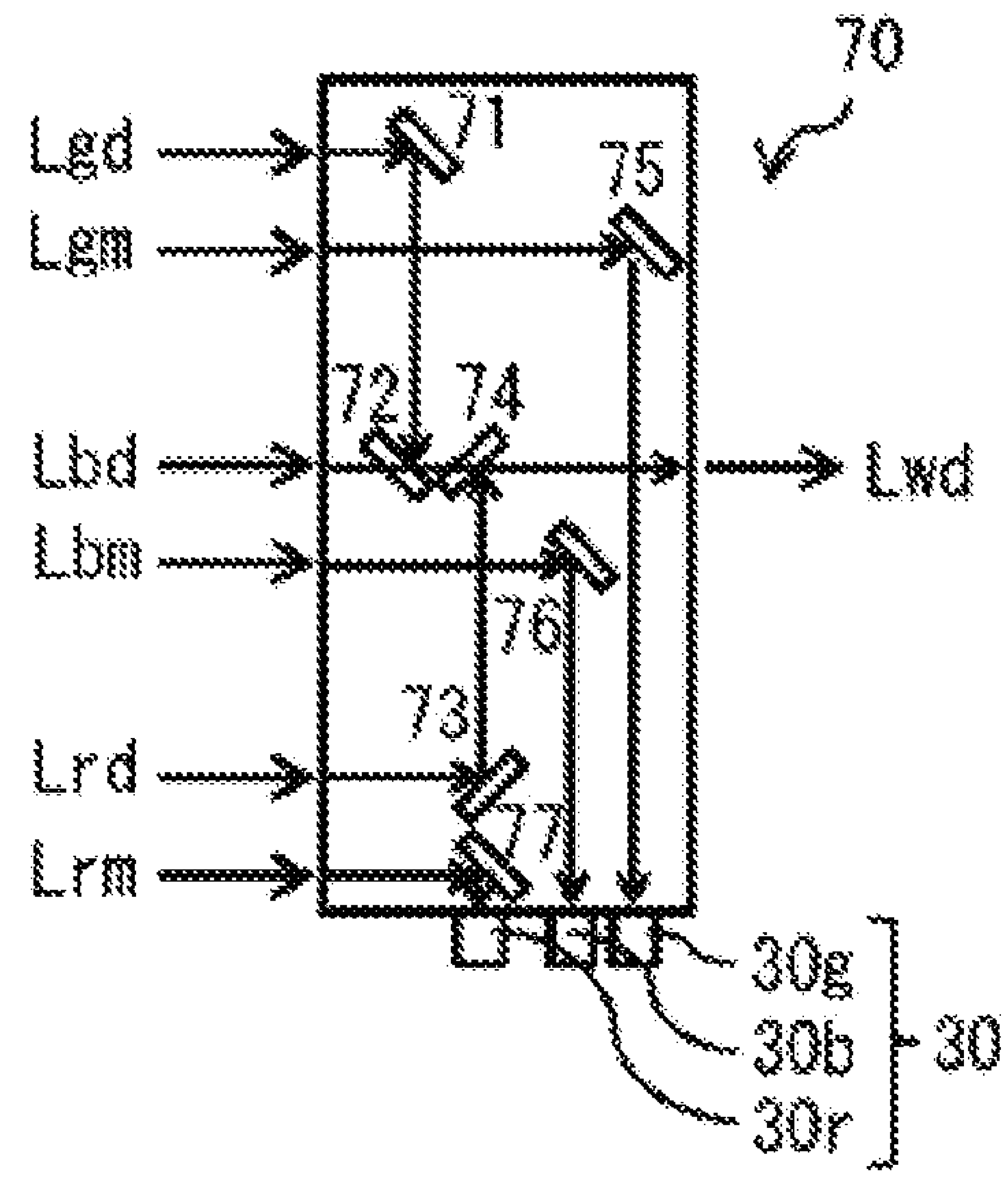
Lgd
Lgm
Lbd
Lbm
Lrd
Lrm
61g
61b
61c
61r
61
Lwd
62g
62b
62r
62
30g
30b
30r
30

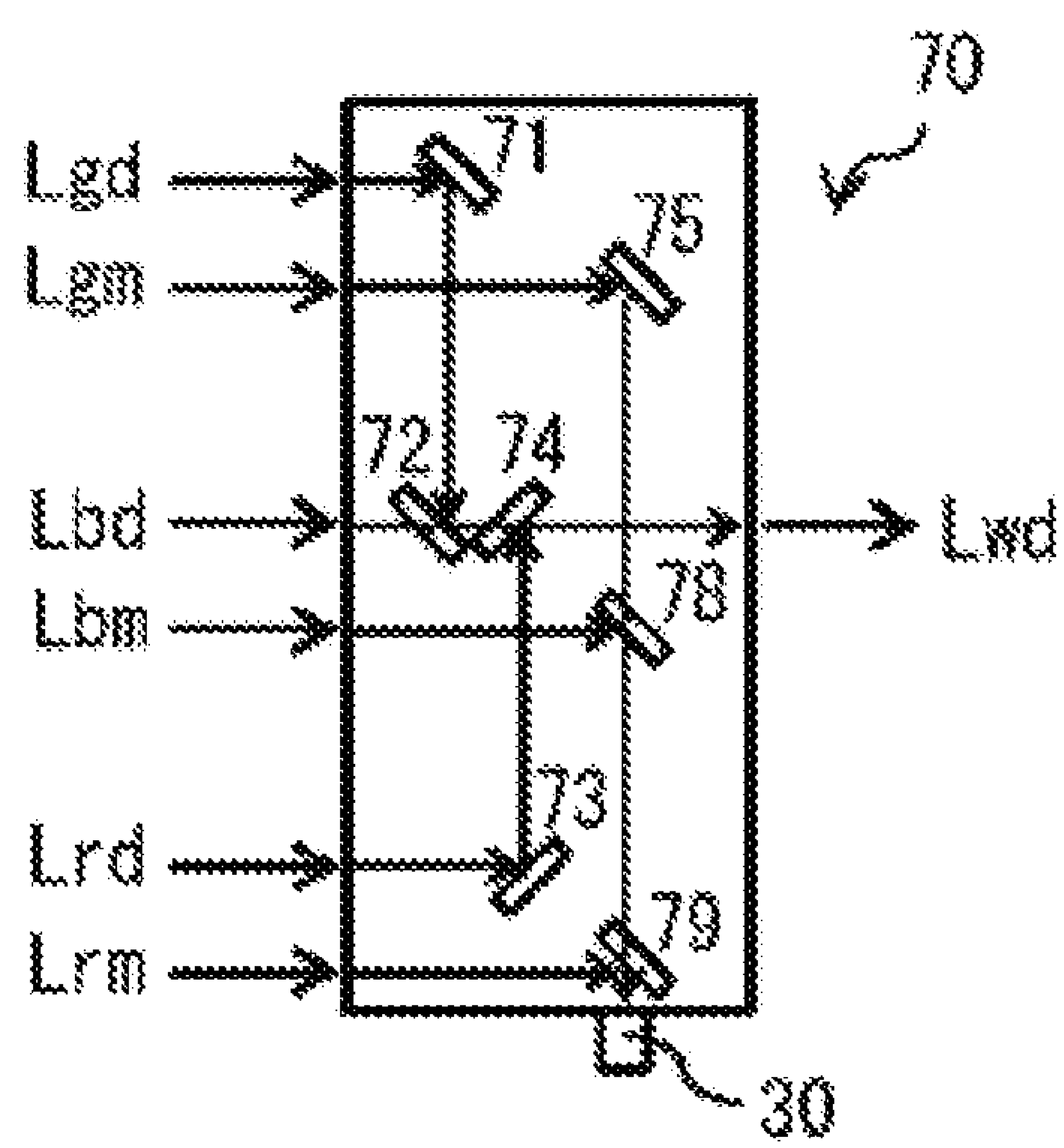
[FIG. 11]


60
Lgd
Lgm
Lbd
Lbm
Lrd
Lrm
61g
61b
61c
61r
61
Lwd
62g
62c
62b
62r
62
30

[FIG. 12]


70
Lgd
71
Lgm
75
72
74
Lbd
Lwd
Lbm
76
73
Lrd
77
Lrm
30g
30b
30
30r

[FIG. 13]


70
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74
Lbd
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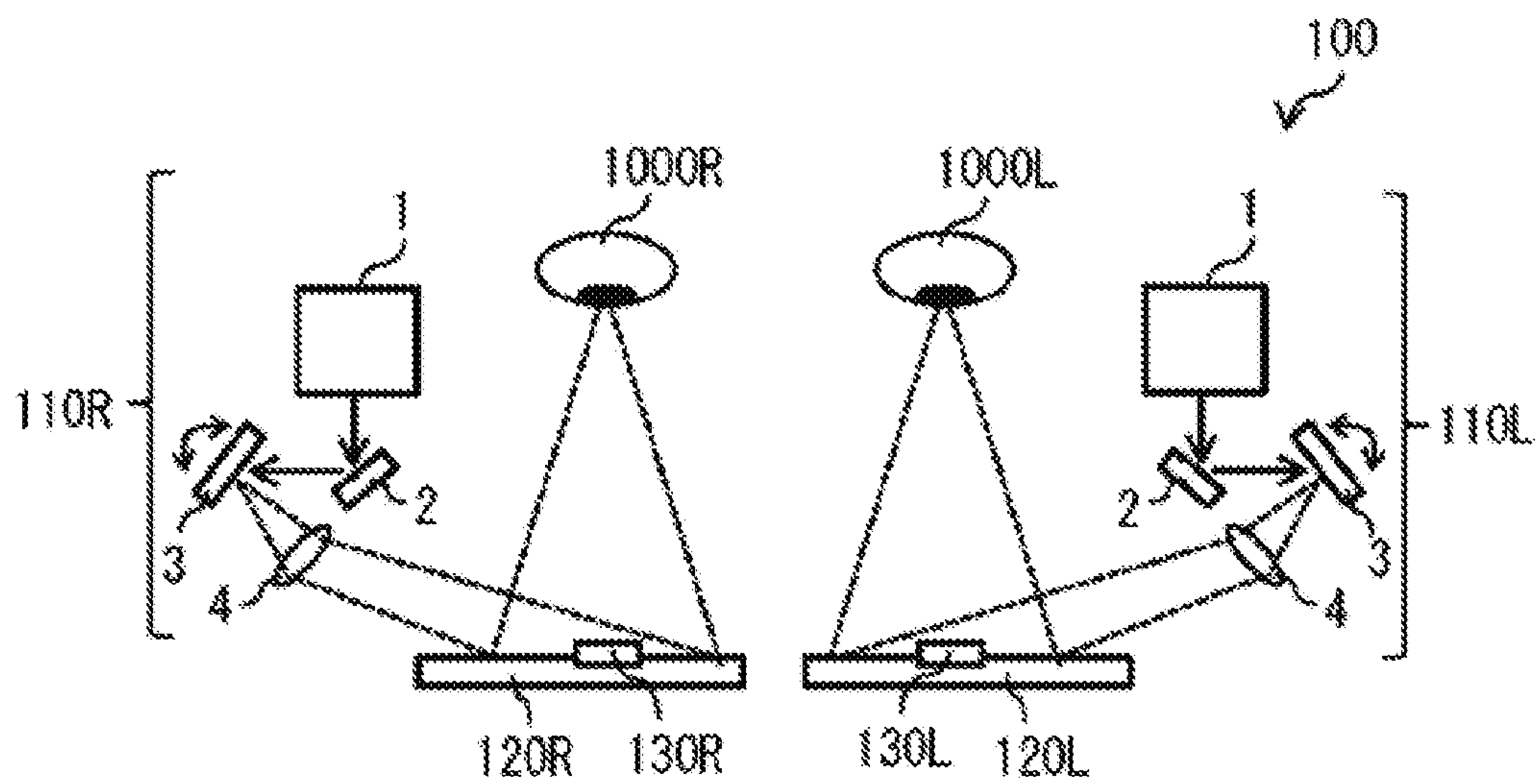
78
73
Lrd
79
Lrm
30

[FIG. 14]



LIGHT SOURCE DEVICE AND ELECTRONIC APPARATUS

TECHNICAL FIELD

[0001] The present disclosure relates to a light source device and an electronic apparatus.

BACKGROUND ART

[0002] As a light source for an AR (Augmented Reality) eyewear or a projector, a technique of multiplexing pieces of laser light of three colors, RGB, through an optical waveguide has been studied. Further, as a light source of an AR eyewear, considerations on VCSEL (surface-emitting laser) have been started as a low-power-consuming and eye-safe light source. Combination of these two techniques makes it possible to achieve a low-power-consuming and ultra-small RGB light source.

CITATION LIST

Patent Literature

[0003] PTL 1: Japanese Unexamined Patent Application Publication No. 2007-25256 PTL 2: Japanese Unexamined Patent Application Publication No. 2006-208794

SUMMARY OF THE INVENTION

[0004] Incidentally, in order to control power of a light source, it is conceivable to monitor light-emitting power of the light source and control a driving current in accordance with a change in the light-emitting power. The light-emitting power is generally monitored by branching light outputted from the light source (see, for example, Patent Literatures 1 and 2). However, in such a case, output power for drawing is reduced. Accordingly, it is desirable to provide a light source device and an electronic apparatus that make it possible to monitor light-emitting power of a light source without reducing output power for drawing.

[0005] A light source device according to a first embodiment of the present disclosure includes a first light source section that outputs first laser light for drawing, and a second light source section that is provided adjacent to the first light source section and outputs second laser light for monitoring. The light source device further includes a light receiver that receives the second laser light, and a controller that performs light emission control on the first light source section on the basis of a detection signal from the light receiver.

[0006] An electronic apparatus according to a second embodiment of the present disclosure includes the light source device according to the first embodiment of the present disclosure.

[0007] In the light source device according to the first embodiment of the present disclosure and the electronic apparatus according to the second embodiment of the present disclosure, the second light source section that outputs the laser light for monitoring is provided adjacent to the first light source section that outputs the first laser light for drawing. This makes it possible to receive the second laser light by the light receiver, and to perform the light emission control on the first light source section on the basis of the detection signal from the light receiver.

[0008] A light source device according to a third embodiment of the present disclosure includes: first light source sections that respectively output pieces of first laser light for drawing having respective light emission wavelengths different from each other; and second light source sections that are each provided adjacent to corresponding one of the first light source sections, and respectively output pieces of second laser light for monitoring having respective wavelengths different from each other. The light source device further includes a light receiver that receives the pieces of second laser light, and a controller that performs light emission control on the first light source sections on the basis of a detection signal from the light receiver.

[0009] An electronic apparatus according to a fourth embodiment of the present disclosure includes the light source device according to the third embodiment of the present disclosure.

[0010] In the light source device according to the third embodiment of the present disclosure and the electronic apparatus according to the fourth embodiment of the present disclosure, the second light source sections that respectively output pieces of second laser light for monitoring having respective wavelengths different from each other are each provided adjacent to corresponding one of the first light source sections that respectively output pieces of first laser light for drawing. This makes it possible to receive the pieces of second laser light by the light receiver, and to perform the light emission control on the first light source section on the basis of the detection signal from the light receiver.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. **1** is a diagram illustrating a schematic configuration example of a light source device according to an embodiment of the present disclosure.

[0012] FIG. **2** is a diagram illustrating an internal configuration example of an optical waveguide section of FIG. **1**.

[0013] FIG. **3** is a diagram illustrating an example of a drive waveform of a light source of FIG. **1**.

[0014] FIG. **4** is a diagram illustrating an example of the drive waveform of the light source of FIG. **1**.

[0015] FIG. **5** is a diagram illustrating an example of an I-L characteristic of the light source of FIG. **1**.

[0016] FIG. **6** is a diagram illustrating an example of the I-L characteristic of the light source of FIG. **1**.

[0017] FIG. **7** is a diagram illustrating a modification example of the light source device of FIG. **1**.

[0018] FIG. **8** is a diagram illustrating an internal configuration example of an optical waveguide section of FIG. **7**.

[0019] FIG. **9** is a diagram illustrating an example of the drive waveform of the light source of FIG. **1**.

[0020] FIG. **10** is a diagram illustrating an internal configuration example of the optical waveguide section of FIG. **2**.

[0021] FIG. **11** is a diagram illustrating an internal configuration example of the optical waveguide section of FIG. **8**.

[0022] FIG. **12** is a diagram illustrating an internal configuration example of the optical waveguide section of FIG. **2**.

[0023] FIG. **13** is a diagram illustrating an internal configuration example of the optical waveguide section of FIG. **8**.

[0024] FIG. **14** is a diagram illustrating an application example of the light source device.

MODES FOR CARRYING OUT THE INVENTION

[0025] In the following, description is given in detail of embodiments of the present disclosure with reference to the drawings. The following description is merely a specific example of the present disclosure, and the present disclosure should not be limited to the following aspects. Moreover, the present disclosure is not limited to arrangements, dimensions, dimensional ratios, and the like of each component illustrated in the drawings. It is to be noted that the description is given in the following order.

1. Embodiment

[0026] An example in which light sources are provided separately for drawing and for monitoring and optical waveguides are provided separately for drawing and for monitoring (FIGS. **1** to **6**)

2. Modification Examples

[0027] Modification Example A: an example in which multiple light sources for drawing are provided for each color (FIG. **7**)

[0028] Modification Example B: an example in which optical waveguides for monitoring are combined (FIGS. **8** and **9**)

[0029] Modification Example C: an example in which an optical fiber is used for an optical waveguide (FIGS. **10** and **11**)

[0030] Modification Example D: an example in which a mirror is used for an optical waveguide (FIGS. **12** and **13**)

3. Application Example

[0031] An example in which a light source device is applied to eyeglasses (FIG. **14**)

1. Embodiment

[Configuration]

[0032] A light source device **1** according to an embodiment of the present disclosure will be described. FIG. **1** illustrates a schematic configuration example of the light source device **1**. The light source device **1** is preferably used as an AR eyewear or a light source of a projector. The light source device **1** includes a light source section **10**, an optical waveguide section **20**, a light receiver **30**, a controller **40**, and a storage **50**.

[0033] The light source section **10** includes multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing and multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring. The light source sections **11**Gd, **11**Bd, and **11**Rd respectively output pieces of laser light Lgd, Lbd, and Lrd for drawing having respective light emission wavelengths different from each other. The light source sections **11**Gm, **11**Bm, and **11**Rm respectively output pieces of laser light Lgm, Lbm, and Lrm for monitoring having respective light emission wavelength different from each other. The multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring have light emission wavelengths equal to light emission wavelengths of the light source sections **11**Gm, **11**Bm, and **11**Rm for drawing.

[0034] The light source section **11**Gd outputs, for example, the green laser light Lgd (for example, a waveband of higher than or equal to 500 nm and lower than or equal to 550 nm). The light source section **11**Gm outputs, for example, the green laser light Lgm. The light source sections **11**Gd and **11**Gm include respective surface-emitting semiconductor light-emitting elements (VCSELs) provided on a common crystal growth substrate and having a common light emission wavelength. The light source sections **11**Gd and **11**Gm include, for example, a GaInN-based semiconductor material. The light source section **11**Gm is provided adjacent to the light source section **11**Gd, and includes the same material as and has the same layer structure as the light source section **11**Gd. Accordingly, a similarity between a light emission characteristic of the light source section **11**Gm and a light emission characteristic of the light source section **11**Gd is high.

[0035] The light source section **11**Bd outputs, for example, the blue laser light Lbd (for example, a waveband of higher than or equal to 430 nm and lower than or equal to 500 nm). The light source section **11**Bm outputs, for example, the blue laser light Lbm. The light source sections **11**Bd and **11**Bm include respective surface-emitting semiconductor light-emitting elements (VCSELs) provided on a common crystal growth substrate and having a common light emission wavelength. The light source sections **11**Bd and **11**Bm include, for example, a GaInN-based semiconductor material. The light source section **11**Bm is provided adjacent to the light source section **11**Bd, and includes the same material as and has the same layer structure as the light source section **11**Bd. Accordingly, a similarity between a light emission characteristic of the light source section **11**Bm and a light emission characteristic of the light source section **11**Bd is high.

[0036] The light source section **11**Rd outputs, for example, the red laser light Lrd (for example, a waveband of higher than or equal to 610 nm and lower than or equal to 780 nm). The light source section **11**Rm outputs, for example, the red laser light Lrm. The light source sections **11**Rd and **11**Rm include respective surface-emitting semiconductor light-emitting elements (VCSELs) provided on a common crystal growth substrate and having a common light emission wavelength. The light source sections **11**Rd and **11**Rm include, for example, a GaInN-based semiconductor material. The light source section **11**Rm is provided adjacent to the light source section **11**Rd, and includes the same material as and has the same layer structure as the light source section **11**Rd. Accordingly, a similarity between a light emission characteristic of the light source section **11**Rm and a light emission characteristic of the light source section **11**Rd is high.

[0037] FIG. **2** illustrates an internal configuration example of the optical waveguide section **20**. The optical waveguide section **20** includes an optical waveguide **21** and an optical waveguide **22**. The optical waveguides **21** and **22** are each, for example, a planar lightwave circuit (PLC), and each include, for example, a core having a high refractive index, and a clad surrounding the core and having a refractive index lower than that of the core.

[0038] The optical waveguide **21** guides the pieces of laser light Lgd, Lbd, and Lbd for drawing from the light source sections **11**Gd, **11**Bd, and **11**Rd to an outside. The optical waveguide **21** includes: optical waveguides **21***g*, **21***b*, and **21***r* respectively provided for the light source sections **11**Gd, **11**Bd, and **11**Rd; and a multiplexer **21***c* that combines the optical waveguides **21***g*, **21***b*, and **21***r*. The optical waveguide **21***g* guides the laser light Lgd for drawing from the light source section **11**Gd to the multiplexer **21***c*. The optical waveguide **21***b* guides the laser light Lbd for drawing from the light source section **11**Bd to the multiplexer **21***c*. The optical waveguide **21***r* guides the laser light Lrd for drawing from the light source section **11**Rd to the multiplexer **21***c*. The multiplexer **21***c* is, for example, an optical component that combines the optical waveguides **21***g*, **21***b*, and **21***r*. The multiplexer **21***c*, for example, multiplexes the pieces of laser light Lgd, Lbd, and Lrd respectively transmitted through the optical waveguides **21***g*, **21***b*, and **21***r*, and guides the multiplexed light to one optical waveguide.

[0039] The optical waveguide **22** is an optical waveguide separate from the optical waveguide **21**. The optical waveguide **22** guides the pieces of laser light Lgm, Lbm, and Lbm for monitoring from the light source sections **11**Gm, **11**Bm, and **11**Rm to the light receiver **30**. The optical waveguide **22** includes optical waveguides **22***g*, **22***b*, and **22***r* respectively provided for the light source sections **11**Gm, **11**Bm, and **11**Rm. The optical waveguide **22***g* guides the laser light Lgd for drawing from the light source section **11**Gm to a light receiver **30***g* (to be described below). The optical waveguide **22***b* guides the laser light Lbd for drawing from the light source section **11**Bm to a light receiver **30***b* (to be described below). The optical waveguide **22***r* guides the laser light Lrd for drawing from the light source section **11**Rm to a light receiver **30***r* (to be described below).

[0040] The light receiver **30** receives the pieces of laser light Lgm, Lbm, and Lbm for monitoring. The light receiver **30** includes the light receiver **30***g* that receives the laser light Lgm for monitoring, the light receiver **30***b* that receives the laser light Lbm for monitoring, and the light receiver **30***r* that receives the laser light Lrm for monitoring. The light receivers **30***g*, **30***b*, and **30***r* each include, for example, a photodiode that photoelectrically converts light in the visible region.

[0041] The storage **50** stores correction data to be used for control of light-emitting power of the light source sections **11**Gd, **11**Bd, and **11**Rd. The storage **50** includes, for example, a nonvolatile memory such as a flash memory. The correction data may include, for example, I-L characteristic data (see FIG. **5**) or I-L-T characteristic data (see FIG. **6**), and relative error data.

[0042] The controller **40** performs light emission control on the light source sections **11**Gd, **11**Bd, and **11**Rd on the basis of a detection signal from the light receiver **30**. The controller **40** also performs light emission control on the light source sections **11**Gm, **11**Bm, and **11**Rm. For example, as illustrated in (A) and (B) of FIG. **3**, the controller **40** controls the light-emitting power of each of the light source sections **11**Gd, **11**Bd, and **11**Rd on the basis of a detection signal obtained from the light receiver **30**. The detection signal is obtained when the light emission control is performed on the light source sections **11**Gd, **11**Bd, and **11**Rd and the light source sections **11**Gm, **11**Bm, and **11**Rm using respective drive signals identical to each other. Hereinafter, the light emission control in such a case is referred to as first light emission control. When the first light emission control is being performed, active-layer temperature of each of the light source sections **11**Gm, **11**Bm, and **11**Rm is approximately equal to active-layer temperature of each of the light source sections **11**Gd, **11**Bd, and **11**Rd. Further, light-emitting power of each of the pieces of laser light Lgm, Lbm, and Lrm outputted from the light source sections **11**Gm, **11**Bm, and **11**Rm is approximately equal to light-emitting power of each of the pieces of laser light Lgd, Lbd, and Lrd outputted from the light source sections **11**Gd, **11**Bd, and **11**Rd.

[0043] The controller **40** measures an I-L characteristic of each of the light source sections **11**Gm, **11**Bm, and **11**Rm when performing the first light emission control. Specifically, as illustrated in (A) and (B) of FIG. **4**, when performing the first light emission control, the controller **40** temporarily applies, to the light source sections **11**Gm, **11**Bm, and **11**Rm, a drive signal (a measurement drive signal) that is different from the drive signal to be applied to the light source sections **11**Gd, **11**Bd, and **11**Rd, for example. The controller **40** applies the measurement drive signal to the light source sections **11**Gm, **11**Bm, and **11**Rm, thereby obtaining a detection signal from the light receiver **30**. On the basis of the thus obtained detection signal, the controller **40** derives the I-L characteristic data of each of the light source sections **11**Gm, **11**Bm, and **11**Rm.

[0044] In FIG. **5**, the I-L characteristic data stored in the storage **50** as initial data is indicated by a dashed line, and the I-L characteristic data derived by the controller **40** is indicated by a solid line. A reason why the two pieces of I-L characteristic data differ from each other is that, for example, the light source sections **11**Gm, **11**Bm, and **11**Rm have changed due to aging.

[0045] The controller **40** may measure I-L-T characteristic data of each of the light source sections **11**Gm, **11**Bm, and **11**Rm when performing the first light emission control. In this case, first, the controller **40** measures active-layer temperature T of each of the light source sections **11**Gm, **11**Bm, and **11**Rm on the basis of the detection signal obtained from the light receiver **30** when performing the first light emission control. The controller **40** measures the active-layer temperature T of each of the light source sections **11**Gm, **11**Bm, and **11**Rm using, for example, the following equation.

$$T=F(I, P)$$

[0046] I: electric current I flowing in each of the light source sections **11**Gm, **11**Bm, and **11**Rm (a value set by the controller **40**)

[0047] P: light-emitting power P of each of the light source sections **11**Gm, **11**Bm, and **11**Rm obtained on the basis of the detection signal obtained from the light receiver **30**

[0048] F(I, P): a mathematical function using the electric current I (a value set by the controller **40**) and the light-emitting power P as parameters

[0049] Thereafter, the controller **40** derives the I-L-T characteristic data of each of the light source sections **11**Gm, **11**Bm, and **11**Rm on the basis of: the obtained active-layer temperature T; and the detection signal obtained from the light receiver **30** by applying the measurement drive signal to the light source sections **11**Gm, **11**Bm, and **11**Rm. That is, the controller **40** derives the I-L-T characteristic data of each of the light source sections **11**Gm, **11**Bm, and **11**Rm on the basis of: the detection signal obtained from the light receiver **30** by the first light emission control; and the detection signal obtained from the light receiver **30** by applying the measurement drive signal to the light source sections **11**Gm, **11**Bm, and **11**Rm.

[0050] In FIG. **6**, the I-L-T characteristic data stored in the storage **50** as initial data is indicated by a dashed line, and the I-L-T characteristic data derived by the controller **40** is indicated by a solid line. A reason why the two pieces of I-L characteristic data differ from each other is that, for example, the light source sections **11**Gm, **11**Bm, and **11**Rm have changed due to aging.

[Effects]

[0051] Next, effects of the light source device **1** according to the present embodiment will be described.

[0052] As a light source for an AR eyewear or a projector, a technique of multiplexing pieces of laser light of three colors, RGB, through an optical waveguide has recently been studied. Further, as a light source of an AR eyewear, considerations on VCSEL have been started as a low-power-consuming and eye-safe light source. Combination of these two techniques makes it possible to achieve a low-power-consuming and ultra-small RGB light source.

[0053] Incidentally, in order to control power of a light source, it is conceivable to monitor light-emitting power of the light source and control a driving current in accordance with a change in the light-emitting power. The light-emitting power is generally monitored by branching light outputted from the light source.

[0054] For example, in the invention disclosed in PTL 1, array optical waveguides coupled to light-emitting elements each include a main waveguide and a branch waveguide in each waveguide, and the branch waveguides combine together to configure a coupled waveguide. Light outputted from the coupled waveguide is received by one light receiving element. Further, for example, the invention disclosed in PTL 2 provides a light-emitting element, and an optical waveguide that guides the light outputted from the light-emitting element. A notch is provided in a portion of the optical waveguide, and light leaked from the notch is monitored by the light receiving element.

[0055] However, in each of the inventions disclosed in PTLs 1 and 2, multiple light-emitting elements output light simultaneously during image drawing, and it is not possible to control light-emitting power for each light-emitting element. Further, some of the light outputted from the light-emitting element is branched to the light receiving element, and thus the light-emitting power of the light used for image drawing is lowered. Further, in a case where light emission for light emission control is performed separately from light emission for drawing, a user can visually recognize the light emission for the light emission control.

[0056] In contrast, the present embodiment provides the multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring each provided adjacent to corresponding one of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing. Thus, it is possible to receive the multiple pieces of laser light Lgm, Lbm, and Lrm for monitoring by the light receiver **30**, and to perform the light emission control on the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing on the basis of the detection signal from the light receiver **30**. As a result, it is possible to monitor the light-emitting power of each of the light source sections **11**Gd, **11**Bd, and **11**Rd without reducing the output power for drawing.

[0057] Further, in the present embodiment, the light source section **11**Gd for drawing and the light source section **11**Gm for monitoring include the respective semiconductor light-emitting elements provided on the common semiconductor substrate. Further, the light source section **11**Bd for drawing and the light source section **11**Bm for monitoring include the respective semiconductor light-emitting elements provided on the common semiconductor substrate. The light source section **11**Rd for drawing and the light source section **11**Rm for monitoring include the respective semiconductor light-emitting elements provided on the common semiconductor substrate. This increases the similarity between the light emission characteristic of the light source section **11**Gm for monitoring and the light emission characteristic of the light source section **11**Gd for drawing. Further, this increases the similarity between the light emission characteristic of the light source section **11**Bm for monitoring and the light emission characteristic of the light source section **11**Bd for drawing. Further, this increases a similarity between a light emission characteristic of each of the multiple pieces of laser light Lgm, Lbm, and Lrm for monitoring and the light emission characteristic of the light source section **11**Rd for drawing. As a result, it is possible to store a relative error between the light emission characteristic of the light source section **11**Gm for monitoring and the light emission characteristic of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing in the storage **50** in advance as the correction data, and to use the relative error for the light emission control.

[0058] Further, in the present embodiment, the light-emitting power of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing is controlled on the basis of the detection signal obtained from the light receiver **30** when the first light emission control is performed. Here, when the first light emission control is performed, the active-layer temperature of each of the light source sections **11**Gm, **11**Bm, and **11**Rm is approximately equal to the active-layer temperature of each of the light source sections **11**Gd, **11**Bd, and **11**Rd. Further, the light-emitting power of each of the pieces of laser light Lgm, Lbm, and Lrm outputted from the light source sections **11**Gm, **11**Bm, and **11**Rm is approximately equal to the light-emitting power of each of the pieces of laser light Lgd, Lbd, and Lrd outputted from the light source sections **11**Gd, **11**Bd, and **11**Rd. It is therefore possible to accurately control the light-emitting power of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing on the basis of the detection signal obtained by the light receiver **30** receiving the multiple pieces of laser light Lgm, Lbm, and Lrm for monitoring.

[0059] Further, in the present embodiment, the light-emitting power of each of the multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring is controlled on the basis of: the detection signal (a second detection signal) obtained from the light receiver **30** when the drive signal that is different from the drive signal to be applied to the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing is applied to the multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring; and the detection signal obtained by the first light emission control. Here, it is possible to derive the active-layer temperature T of each of the multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring from the second detection signal, and also to control the light-emitting power of each of the multiple light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring on the basis of the I-L characteristic data corresponding to the derived active-layer temperature T. As a result, it is possible to control with high accuracy the light-emitting power of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing.

2. Modification Examples

[0060] Next, modification examples of the light source device **1** according to the above-described embodiment will be described.

Modification Example A

[0061] In the above-described embodiment, for example, as illustrated in FIG. **7**, multiple light source sections **11**Gd that each output the green laser light Lgd may be provided. Further, in the above-described embodiment, for example, as illustrated in FIG. **7**, multiple light source sections **11**Bd that each output the blue laser light Lbd may be provided. Further, in the above-described embodiment, for example, as illustrated in FIG. **7**, multiple light source sections **11**Rd that each output the red laser light Lrd may be provided.

Modification Example B

[0062] In the embodiment and the modification example thereof described above, for example, as illustrated in FIG. **8**, the optical waveguide **22** may include: the optical waveguides **22***g*, **22***b*, and **22***r*; and a multiplexer **22***c* that combines the optical waveguides **22***g*, **22***b*, and **22***r*. In this case, the multiplexer **22***c* is, for example, an optical component that combines the optical waveguides **22***g*, **22***b*, and **22***r*. The multiplexer **22***c*, for example, multiplexes the pieces of laser light Lgm, Lbm, and Lrm respectively transmitted through the optical waveguides **22***g*, **22***b*, and **22***r* and guides the multiplexed light to one optical waveguide. The multiplexed light enters one light receiver **30**. It is therefore possible in the present modification example to reduce the number of light receivers **30** as compared with the above-described embodiment.

[0063] Here, for example, as illustrated in FIG. **9**, it is possible for the controller **30** to perform the light emission control on each of the light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring by sequentially causing the light source sections **11**Gm, **11**Bm, and **11**Rm for monitoring to output light in time-series order.

Modification Example C

[0064] In the embodiment and the modification examples thereof described above, for example, as illustrated in FIGS. **10** and **11**, an optical waveguide section **60** may be provided instead of the optical waveguide section **20**. The optical waveguide section **60** corresponds to the optical waveguide section **20** in which all the optical waveguides are replaced with optical fibers. As described above, in a case where the optical fibers are used also, it is possible to accurately control the light-emitting power of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing as with the above-described embodiment.

Modification Example D

[0065] In the embodiment and the modification examples thereof described above, for example, as illustrated in FIGS. **12** and **13**, an optical waveguide section **70** may be provided instead of the optical waveguide section **20**. The optical waveguide section **70** corresponds to, for example, as illustrated in FIG. **12**, the optical waveguide section **20** in which: the optical waveguides are omitted; reflection mirrors **71** and **73** and dichroic mirrors **72** and **74** are provided in optical paths of the pieces of laser light Lgd, Lbd, and Lrd; and reflection mirrors **75**, **76**, and **77** are provided in optical paths of the pieces of laser light Lgm, Lbm, and Lrm. Further, the optical waveguide section **70** corresponds to, for example, as illustrated in FIG. **13**, the optical waveguide section **20** in which: the optical waveguides are omitted; the reflection mirrors **71** and **73** and the dichroic mirrors **72** and **74** are provided in the optical paths of the pieces of laser light Lgd, Lbd, and Lrd; and the reflection mirror **75** and dichroic mirrors **78** and **79** are provided in the optical paths of the pieces of laser light Lgm, Lbm, and Lrm. As described above, in a case where the reflection mirrors and the dichroic mirrors are used also, it is possible to accurately control the light-emitting power of each of the multiple light source sections **11**Gd, **11**Bd, and **11**Rd for drawing as with the above-described embodiment.

3. Application Example

[0066] Next, an application example of the light source device **1** according to the embodiment and the modification examples thereof described above will be described.

[0067] FIG. **14** illustrates a schematic configuration example of eyeglasses **100** including the light source device **1** according to the embodiment and the modification examples thereof described above. The eyeglasses **100** include an image projector **110**R for a right eye, a combiner **120**R for the right eye, and an imaging section **130**R for the right eye. The eyeglasses **100** further include an image projector **110**L for a left eye, a combiner **120**L for the left eye, and an imaging section **130**L for the left eye.

[0068] The image projectors **110**R and **110**L each includes a light source device **1**(R) that outputs R (red) light, a light source device **1**(G) that outputs G (green) light, a light source device **1**(B) that outputs B (blue) light, and an optical waveguide **2** that multiplexes the R light, the G light, and the B light. The image projector **110**R further includes a mirror **3** that reflects white light generated by the multiplexing performed by the optical waveguide **2**, and a scan mirror **4** that scans biaxially a surface of the combiner **120**R via a lens **5** using the white light reflected by the mirror **3**. The image projector **110**L further includes a mirror **3** that reflects white light generated by the multiplexing performed by the optical waveguide **2**, and a scan mirror **4** that scans biaxially a surface of the combiner **120**L via a lens **5** using the white light reflected by the mirror **3**.

[0069] The combiner **120**R diffracts light drawn on the surface of the combiner **120**R by the image projector **110**R and projects the light onto a retina of a right eye **1000**R. The imaging section **130**R performs imaging to thereby acquire image data including the right eye **1000**R, and detects a position of the right eye **1000**R on the basis of the acquired image data. The imaging section **130**R outputs the detected position of the right eye **1000**R to the image projector **110**R. The image projector **110**R controls the scanning of the scan mirror **4** in such a manner that the light is projected at the position of the right eye **1000**R obtained from the imaging section **130**R.

[0070] The combiner **120**L diffracts light drawn on the surface of the combiner **120**L by the image projector **110**L and projects the light onto a retina of a left eye **1000**L. The imaging section **130**L performs imaging to thereby acquire image data including the left eye **1000**L, and detects a position of the left eye **1000**L on the basis of the acquired image data. The imaging section **130**L outputs the detected position of the left eye **1000**L to the image projector **110**L.

The image projector **110**L controls the scanning of the scan mirror **4** in such a manner that the light is projected at the position of the left eye **1000**L obtained from the imaging section **130**L.

[0071] In the present application example, the light source device **1** according to the embodiment and the modification examples thereof described above is used as a light source of each of the image projectors **110**R and **110**L. It is therefore possible to perform light combining and light-output monitoring with an easily-achievable configuration by the image projectors **110**R and **110**L.

[0072] Although the disclosure is described hereinabove with reference to the example embodiment and modification examples, these embodiments are not to be construed as limiting the scope of the disclosure and may be modified in a wide variety of ways. It should be appreciated that the effects described herein are mere examples. Effects of the example embodiment and modification examples of the disclosure are not limited to those described herein. The disclosure may further include any effects other than those described herein. Further, the present disclosure may also have the following configurations.

[0073] (1)

[0074] A light source device including:

[0075] a first light source section that outputs first laser light for drawing;

[0076] a second light source section that is provided adjacent to the first light source section, and outputs second laser light for monitoring;

[0077] a light receiver that receives the second laser light; and

[0078] a controller that performs light emission control on the first light source section on a basis of a detection signal from the light receiver.

[0079] (2)

[0080] The light source device according to (1), in which the first light source section and the second light source section include respective semiconductor light-emitting elements provided on a common semiconductor substrate and having a common light emission wavelength.

[0081] (3)

[0082] The light source device according to (2), in which the controller controls light-emitting power of the first light source section on a basis of a first detection signal obtained from the light receiver, the first detection signal being obtained when the light emission control is performed on the first light source section and the second light source section using respective drive signals identical to each other.

[0083] (4)

[0084] The light source device according to (3), in which the controller controls the light-emitting power of the first light source section on a basis of a second detection signal obtained from the light receiver, the second detection signal being obtained when the controller applies, to the second light source section, a drive signal that is different from a drive signal to be applied to the first light source section.

[0085] (5)

[0086] The light source device according to (4), further including

[0087] a storage that stores correction data to be used for control of the light-emitting power of the first light source section, in which

[0088] the controller controls the light-emitting power of the first light source section on a basis of the first detection signal, the second detection signal, and the correction data.

[0089] (6)

[0090] The light source device according to any one of (1) to (5), further including:

[0091] a first optical waveguide that guides the first laser light from the first light source section to an outside; and

[0092] a second optical waveguide that guides the second laser light from the second light source section to the light receiver, the second optical waveguide being separate from the first optical waveguide.

[0093] (7)

[0094] The light source device according to any one of (1) to (5), further including:

[0095] a first optical fiber that guides the first laser light from the first light source section to an outside; and

[0096] a second optical fiber that guides the second laser light from the second light source section to the light receiver, the second optical fiber being different from the first optical fiber.

[0097] (8)

[0098] A light source device including:

[0099] first light source sections that respectively output pieces of first laser light for drawing having respective light emission wavelengths different from each other;

[0100] second light source sections that are each provided adjacent to corresponding one of the first light source sections, and respectively output pieces of second laser light for monitoring having respective wavelengths different from each other;

[0101] a light receiver that receives the pieces of second laser light; and

[0102] a controller that performs light emission control on the first light source sections on a basis of a detection signal from the light receiver.

[0103] (9)

[0104] The light source device according to (8), in which

[0105] each of the second light source sections and corresponding one of the first light source sections that have a common light emission wavelength are provided adjacent to each other, and

[0106] the first light source section and the second light source section having the common light emission wavelength include respective semiconductor light-emitting elements provided on a common semiconductor substrate.

[0107] (10)

[0108] The light source device according to (9), in which the controller controls light-emitting power of each of the first light source sections on a basis of a first detection signal obtained from the light receiver, the first detection signal being obtained when the light emission control is performed on each set of the first light source section and the second light source section having the common light emission wavelength using respective drive signals identical to each other.

[0109] (11)

[0110] The light source device according to (10), in which the controller controls the light-emitting power of each of the first light source sections on a basis of a second detection signal obtained from the light receiver, the second detection signal being obtained when the controller applies, to each of the second light source sections, a drive signal that is different from a drive signal to be applied to the first light source section having the common light emission wavelength.

[0111] (12)

[0112] The light source device according to (11), further including

[0113] a storage that stores correction data to be used for control of the light-emitting power of each of the first light source sections, in which

[0114] the controller controls the light-emitting power of each of the first light source sections on a basis of the first detection signal, the second detection signal, and the correction data.

[0115] (13)

[0116] The light source device according to any one of (8) to (12), further including:

[0117] a first optical waveguide that guides the first laser light from each of the first light source sections to an outside; and

[0118] a second optical waveguide that guides the second laser light from each of the second light source sections to the light receiver, the second optical waveguide being separate from the first optical waveguide.

[0119] (14)

[0120] The light source device according to (13), in which

[0121] the first optical waveguide includes

[0122] third optical waveguides respectively provided for the first light source sections, and

[0123] a first multiplexer that combines the third optical waveguides,

[0124] the second optical waveguide includes fourth optical waveguides respectively provided for the second light source sections, and

[0125] the light receiver includes light receiving elements respectively provided for the fourth optical waveguides.

[0126] (15)

[0127] The light source device according to (13), in which

[0128] the first optical waveguide includes

[0129] third optical waveguides respectively provided for the first light source sections, and

[0130] a first multiplexer that combines the third optical waveguides, and the second optical waveguide includes

[0131] fourth optical waveguides respectively provided for the first light source sections, and

[0132] a second multiplexer that combines the fourth optical waveguides.

[0133] (16)

[0134] The light source device according to (8), further including:

[0135] a first optical fiber that guides the first laser light from each of the first light source sections to an outside; and

[0136] a second optical fiber that guides the second laser light from each of the second light source sections to the light receiver, the second optical fiber being different from the first optical fiber.

[0137] (17)

[0138] The light source device according to (16), in which

[0139] the first optical fiber includes

[0140] third optical fibers respectively provided for the first light source sections, and

[0141] a first multiplexer that combines the third optical fibers,

[0142] the second optical fiber includes fourth optical fibers respectively provided for the second light source sections, and

[0143] the light receiver includes light receiving elements respectively provided for the fourth optical waveguides.

[0144] (18)

[0145] The light source device according to (16), in which

[0146] the first optical fiber includes

[0147] third optical fibers respectively provided for the first light source sections, and

[0148] a first multiplexer that combines the third optical fibers, and

[0149] the second optical fiber includes

[0150] fourth optical fibers respectively provided for the second light source sections, and

[0151] a second multiplexer that combines the fourth optical fibers.

[0152] (19)

[0153] An electronic apparatus including

[0154] a light source device, in which

[0155] the light source device includes

[0156] a first light source section that outputs first laser light for drawing,

[0157] a second light source section that is provided adjacent to the first light source section, and outputs second laser light for monitoring,

[0158] a light receiver that receives the second laser light, and

[0159] a controller that performs light emission control on the first light source section on a basis of a detection signal from the light receiver.

[0160] (20)

[0161] An electronic apparatus including

[0162] a light source device, in which

[0163] the light source device includes

[0164] first light source sections that respectively output pieces of first laser light for drawing having respective wavelengths different from each other,

[0165] second light source sections that are each provided adjacent to corresponding one of the first light source sections, and respectively output pieces of second laser light for monitoring having respective wavelengths different from each other,

[0166] a light receiver that receives the pieces of second laser light, and

[0167] a controller that performs light emission control on the first light source sections on a basis of a detection signal from the light receiver.

[0168] In the light source device according to the first embodiment of the present disclosure and the electronic apparatus according to the second embodiment of the present disclosure, the second light source section that outputs the laser light for monitoring is provided adjacent to the first light source section that outputs the first laser light for drawing. This makes it possible to receive the second laser light by the light receiver, and to perform the light emission control on the first light source section on the basis of the detection signal from the light receiver. As a result, it is possible to monitor the light-emitting power of the light source without reducing the output power for drawing.

[0169] In the light source device according to the third embodiment of the present disclosure and the electronic apparatus according to the fourth embodiment of the present disclosure, the second light source sections that respectively output pieces of second laser light for monitoring having respective wavelengths different from each other are each provided adjacent to corresponding one of the first light source sections that respectively output pieces of first laser light for drawing. This makes it possible to receive the pieces of second laser light by the light receiver, and to perform the light emission control on the first light source section on the basis of the detection signal from the light receiver. As a result, it is possible to monitor the light-emitting power of the light source without reducing the output power for drawing. It is to be noted that the effects of the present disclosure are not necessarily limited to the effects described herein, and may be any effects described herein.

[0170] This application claims the benefit of Japanese Priority Patent Application JP2021-119675 filed with the Japan Patent Office on Jul. 20, 2021, the entire contents of which are incorporated herein by reference.

[0171] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations, and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

1. A light source device comprising:

a first light source section that outputs first laser light for drawing;

a second light source section that is provided adjacent to the first light source section, and outputs second laser light for monitoring;

a light receiver that receives the second laser light; and

a controller that performs light emission control on the first light source section on a basis of a detection signal from the light receiver.

2. The light source device according to claim **1**, wherein the first light source section and the second light source section comprise respective semiconductor light-emitting elements provided on a common semiconductor substrate and having a common light emission wavelength.

3. The light source device according to claim **2**, wherein the controller controls light-emitting power of the first light source section on a basis of a first detection signal obtained from the light receiver, the first detection signal being obtained when the light emission control is performed on the first light source section and the second light source section using respective drive signals identical to each other.

4. The light source device according to claim **3**, wherein the controller controls the light-emitting power of the first light source section on a basis of a second detection signal obtained from the light receiver, the second detection signal being obtained when the controller applies, to the second light source section, a drive signal that is different from a drive signal to be applied to the first light source section.

5. The light source device according to claim **4**, further comprising

a storage that stores correction data to be used for control of the light-emitting power of the first light source section, wherein

the controller controls the light-emitting power of the first light source section on a basis of the first detection signal, the second detection signal, and the correction data.

6. The light source device according to claim **1**, further comprising:

a first optical waveguide that guides the first laser light from the first light source section to an outside; and

a second optical waveguide that guides the second laser light from the second light source section to the light receiver, the second optical waveguide being separate from the first optical waveguide.

7. The light source device according to claim **1**, further comprising:

a first optical fiber that guides the first laser light from the first light source section to an outside; and

a second optical fiber that guides the second laser light from the second light source section to the light receiver, the second optical fiber being different from the first optical fiber.

8. A light source device comprising:

first light source sections that respectively output pieces of first laser light for drawing having respective light emission wavelengths different from each other;

second light source sections that are each provided adjacent to corresponding one of the first light source sections, and respectively output pieces of second laser light for monitoring having respective wavelengths different from each other;

a light receiver that receives the pieces of second laser light; and

a controller that performs light emission control on the first light source sections on a basis of a detection signal from the light receiver.

9. The light source device according to claim **8**, wherein

each of the second light source sections and corresponding one of the first light source sections that have a common light emission wavelength are provided adjacent to each other, and

the first light source section and the second light source section having the common light emission wavelength comprise respective semiconductor light-emitting elements provided on a common semiconductor substrate.

10. The light source device according to claim **9**, wherein the controller controls light-emitting power of each of the first light source sections on a basis of a first detection signal obtained from the light receiver, the first detection signal being obtained when the light emission control is performed on each set of the first light source section and the second light source section having the common light emission wavelength using respective drive signals identical to each other.

11. The light source device according to claim **10**, wherein the controller controls the light-emitting power of each of the first light source sections on a basis of a second detection signal obtained from the light receiver, the second detection signal being obtained when the controller applies, to each of the second light source sections, a drive signal that is different from a drive signal to be applied to the first light source section having the common light emission wavelength.

12. The light source device according to claim **11**, further comprising

a storage that stores correction data to be used for control of the light-emitting power of each of the first light source sections, wherein

the controller controls the light-emitting power of each of the first light source sections on a basis of the first detection signal, the second detection signal, and the correction data.

13. The light source device according to claim **8**, further comprising:

a first optical waveguide that guides the first laser light from each of the first light source sections to an outside; and

a second optical waveguide that guides the second laser light from each of the second light source sections to the light receiver, the second optical waveguide being separate from the first optical waveguide.

14. The light source device according to claim **13**, wherein

the first optical waveguide includes

third optical waveguides respectively provided for the first light source sections, and

a first multiplexer that combines the third optical waveguides,

the second optical waveguide includes fourth optical waveguides respectively provided for the second light source sections, and

the light receiver includes light receiving elements respectively provided for the fourth optical waveguides.

15. The light source device according to claim **13**, wherein

the first optical waveguide includes

third optical waveguides respectively provided for the first light source sections, and

a first multiplexer that combines the third optical waveguides, and

the second optical waveguide includes

fourth optical waveguides respectively provided for the first light source sections, and

a second multiplexer that combines the fourth optical waveguides.

16. The light source device according to claim **8**, further comprising:

a first optical fiber that guides the first laser light from each of the first light source sections to an outside; and

a second optical fiber that guides the second laser light from each of the second light source sections to the light receiver, the second optical fiber being different from the first optical fiber.

17. The light source device according to claim **16**, wherein

the first optical fiber includes

third optical fibers respectively provided for the first light source sections, and

a first multiplexer that combines the third optical fibers,

the second optical fiber includes fourth optical fibers respectively provided for the second light source sections, and

the light receiver includes light receiving elements respectively provided for the fourth optical waveguides.

18. The light source device according to claim **16**, wherein

the first optical fiber includes

third optical fibers respectively provided for the first light source sections, and

a first multiplexer that combines the third optical fibers, and the second optical fiber includes

fourth optical fibers respectively provided for the second light source sections, and

a second multiplexer that combines the fourth optical fibers.

19. An electronic apparatus comprising

a light source device, wherein

the light source device includes

a first light source section that outputs first laser light for drawing,

a second light source section that is provided adjacent to the first light source section, and outputs second laser light for monitoring,

a light receiver that receives the second laser light, and

a controller that performs light emission control on the first light source section on a basis of a detection signal from the light receiver.

20. An electronic apparatus comprising

a light source device, wherein

the light source device includes

first light source sections that respectively output pieces of first laser light for drawing having respective wavelengths different from each other,

second light source sections that are each provided adjacent to corresponding one of the first light source sections, and respectively output pieces of second laser light for monitoring having respective wavelengths different from each other,

a light receiver that receives the pieces of second laser light, and

a controller that performs light emission control on the first light source sections on a basis of a detection signal from the light receiver.

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